■ Trevor Pearcey photographed a few years ago with Csirac after it found a home at Chisholm Institute of Technology. When it was up and running it was surmounted by a large cooling duct to remove the heat of its 2000 vacuum tubes.

Pioneering age of achievement — and lost chances

FORTY years ago this month a world recovering from the horrors of a world war was presented with a 30-ton prodigy called Eniac. The world was not very impressed; after all this was the decade of the atom bomb, guided missiles, the jet engine, and various other fantastical forms of mass destruction. Eniac's main early contribution to the world at large was to provide headline writers with the description "electronic brain" and cartoonists with a bottomless well of ideas.

Eniac is considered to be the first successful electronic computer, spawned by the necessity of war for use in ballistics research in the US. There had been previous attempts at creating electronic number-crunchers but they had been laboratory models or partial failures.

J Presper Eckert, who with John Mauchly, created Eniac at the University of Pennsylvania, will today draw a parallel with Edison's first successful light bulb. Light bulbs had been around for 25 years but they were not much use; they burnt out in two hours. Edison's lasted for an incredible 40 hours and heralded an age of light undreamt of.

Eniac, with its thousands of vacuum valves, crunched on for 10 years predicting trajectories of missiles — guided and unguided alike — that even today are thriving on the world's killing fields.

But, like Edison's light bulb, Eniac heralded an age of progress and common good. The world will never be the same again; and the revolution continues, affecting every aspect of all but the most undeveloped parts of the world.

While work on Eniac and its successors continued, similar enterprise was taking place in the UK — and to a quite remarkable degree in Australia. At times, through the 1950s, Australia was at the very tip of the leading edge; indeed its scientists were in the forefront.

The tragedy was that the lead was surrendered, frittered away by industrial indifference and political myopia. Three decades later one might draw the comparison with Australia's brilliant work on in vitro fertilisation: world leadership undermined and surrendered through external interference.

One of the people responsible for Australia's unique computing effort was Trevor Pearcey who helped to develop Csir Mk1 — later to be called Csirac — the world's second or third electronic computer, and its several successors.

After a lifetime spent in computing, Pearcey has retired to the Mornington Peninsula. But he is still keenly interested in computing and has recently completed the last draft of a History of Australian Computing. He makes a few trenchant comments about why Australia so abjectly threw away the golden apple to the marketing genius of the US.

Computerworld Australia is proud to mark the 40th Anniversary of the Computer with a section from Pearcey's book dealing with the very early years of research — the days of Csir Mk1, Silliac and Utecom.

Pearcey's work is one of great scholarship and fills a gap in the knowledge of thousands in the computing industry; it is the first full length attempt to record the formative years of Australian computing and pay recognition to the pioneers.

Pearcey hopes to see his book published next year while *Computerworld* expects to carry further edited extracts in coming months. ▶

HISTORY OF AUSTRALIAN COMPUTING

■ *These are the first edited extracts of Trevor Pearcey's planned book History of Australian Computing, and cover the immediate post-war years when Australia was at the forefront of the technology.*

Toward Electronics — 1945 to 1951

THE period from 1945 to 1955 saw the start of the transition from the numerical calculator and analogue instrument to the general purpose electronic stored program computer. During this time interest in analogue devices continued, although waning.

It was becoming clear that the need of scientific research and expansion of industry would cause such a massive increase in the need for information and data handling that new and much faster automatic methods of performing increasingly sophisticated calculations and data handling would be become essential.

This was realised by D M Myers and supported by the late A E Cornish, then chief of the Section (later Division) of Mathematical Statistics of Csir (later Csiro), a section involved in much computation. The tools used were mainly electromechanical and mechanical desktop keyboard calculators such as the Marchant and Brunsviga.

Early in 1946 Myers, supported by Cornish, proposed to the executive of Csir (chairman Sir David Rivett and executive officer F W G White), the formation of a Section of Applied Mathematics, which was to:

■ Research and develop new mathematical methods, devices and instruments.

■ Provide assistance to research and other workers in handling mathematical problems.

■ Provide a computing service requiring use of special facilities, and so on.

■ Advise on needs for new mathematical tables and, if necessary, compute such tables.

It was also proposed that the formation of small specialist groups of mathematicians in divisions be encouraged.

This led to the formation in 1948, in a somewhat modified form, of the Csir's Section of Mathematical Instruments (SMI), under Myers, at the National Standards Laboratory building.

Trevor Pearcey joined the Division of Radiophysics (also sited in the National Standards Laboratory building) at the end of 1945, having graduated from the Imperial College and worked on radar development from 1940, particularly on mathematical problems that called for heavy computation. He was therefore aware of the coming needs.

Pearcey had also worked with the late D R Hartree in Manchester, using the differential analyser there, and a similar machine as well as the Mallock machine (designed to solve up to 10 simultaneous linear equations), both situated at the Mathematical Laboratory of Cambridge University. Through association with L J Comrie, director of the Scientific Computing Service in London, Pearcey became familiar with the various uses of statistical machines such as the BTM punched card and multi-register accounting machines. He had had some discussions with Hartree on possible means of achieving fast computation electronically and had seen Aiken's Automatic Sequence Controlled Calculator (ASCC) at the Cruft Laboratory of Harvard University and the later version of the high precision differential analyser at MIT which had electrical transmission and setup procedures.

Highly secret work

Pearcey was not aware of the existence of the Eniac or the highly secret work carried out by T H Flowers at Bletchley Park on the Colossus, or the relay machines of G R Stibitz and S B Williams at the Bell Laboratories. He was aware of T Gold's work at Haslemere on sonic delay techniques for the enhancement of radar echo signals. The main source of ideas for the logic developments which followed was the 1943 paper by W S McCulloch and W Pitts.

During 1946 and 1947 ideas for electronic high speed computing were being formulated at the Division of Radiophysics. What was known then was:

■ A computational process had to be defined as a sequence of suitably encoded instructions to be made available sequentially, decoded and executed.

■ It was necessary to make those instructions available at a rate similar to that at which they could be executed. (By already established electronic techniques, speeds of control and execution could be of the order of thousands of operations per second, with pulse rates of the order of a million per second.)

■ Paper tape, as used in the ASCC for storage of the instruction lists, or programs, was not a sufficiently fast medium.

■ Storage of all information involved in a computation was essential and the further development of sonic techniques could offer a solution to the storage problem.

■ Arithmetic and other logic functions could be performed at appropriate speeds with known vacuum tube technology and binary scaling counter methods similar to that used in subatomic physics.

■ Because most instructions would main-

ly be executed in an invariant sequence, they could be given serial numbers within a store and could then be accessed under the control of a simple counting register for which techniques were well known.

■ A study of the way in which programs could be easily designed and recorded for operation was needed.

Towards the end of 1947 a complete logical design of a system which satisfied all these requirements, assuming appropriate media were available, had been formulated by Pearcey and M Beard, who had graduated in electrical engineering from Sydney University, had worked in the Division of Radiophysics throughout World War II and was then completing work on distance measuring equipment (DME), a radio device for aircraft and airport control. He and Pearcey formed a team, the former to study the hardware components involved and the latter to pursue the associated theory, define the best instruction set and the programming techniques required for controlling computation.

By the end of 1949 some basic programs had been proved and a working, though incomplete, machine was publicly demonstrated at the first Conference on Automatic Computing Machines at Sydney University in 1951.

The construction of the Csir Mk1, as it was first called, was of standard components available from the well developed radio industry — no miniaturisation or circuit packaging was then possible. The 1.5m sonic delay lines filled with mercury to carry the stored pulses were specially developed by R D Ryan. Another form of auxiliary storage consisting of a rotating drum with a magnetisable surface, designed by B F C Cooper, was installed and eventually special 12-channel paper tape readers and punches, designed by Beard, were incorporated.

Parallel effort

The Mk1 was one of the earliest truly automatic stored program computers. It was only as late as 1948 that the team became aware of the parallel work on the Edsac (Electronic Delay Storage Automatic Computer) at Cambridge under M V Wilkes, the MADM (Manchester Automatic Digital Machine) at Manchester University under T Kilburn and the Pilot ACE (Automatic Computing Engine, after Babbage) at the newly established Mathematics Division of the National Physical Laboratory (NPL), Teddington, under J R Womersley. Pearcey visited those projects during late 1948, but it was decided not to alter the logical structure of the Mk1.

The Mk1 was a programmer's machine structured for engineering simplicity, economy in use of storage capacity which, in those early days, was expensive, and to provide maximum logical functional flexibility consistent with simplicity of programming. Operation was serial and speed was sacrificed in the interests of program economy and flexibility. The main objective was the development of programming techniques to simplify actual application.

A particular difficulty was the unavailability of effective means of input and output instrumentation. Punched card and teleprinter machines were soon replaced by special, faster, 12-channel paper tape punches and readers. These were effective although commercially non-standard. The input and output procedures used originally for card input and output were continued with the new devices and accounted for the adoption of the 12-channel style of paper tape.

All programs were prepared off-line while output was either printed during operation or was punched on to the 12-channel tape and later printed under a printing routine online.

A pulse-interleaving technique of delay storage, developed by R D Ryan, raised the main storage capacity to at most 1024 20-binary digit addressable groups, or words. Each instruction occupied a complete word and was formatted into three segments, two of which indicated the source and destination of a transfer of data while the third addressed the acoustic store.

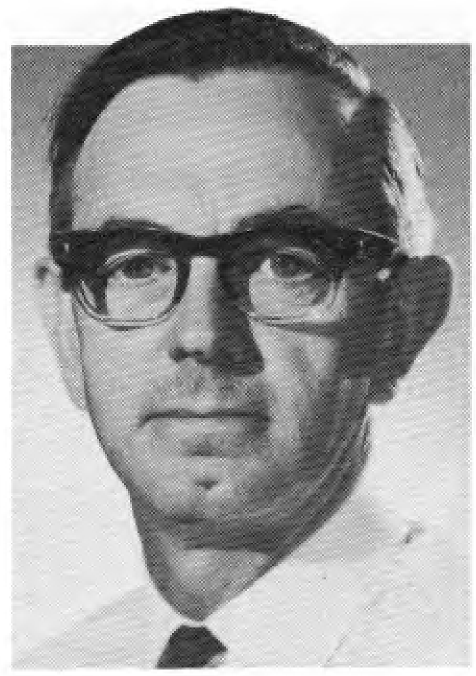
The magnetic drum storage of similar capacity was later extended to 4096 words. The first version had an average access time of only five milliseconds and was comparable with the basic speed of the machine and so was designed to read and write in parallel mode, that is, in 20-bit groups at once, while the main machine operated in serial mode one bit at a time. The main execution speed, originally about 500 instructions/sec, was raised in stages to about 1000 operations/sec.

The machine contained about 2000 vacuum tubes and required about 30kW of power. The heat was dissipated by force-draughting cool basement air to the exterior. The acoustic store and registers were thermally controlled at above ambient temperature to improve the stability of the delay store.

The development of the instruction set and programming techniques were assisted by BTM punched card equipment, installed and operated by Pearcey during 1948-54. This was applied to scientific computations such as mathematical tabulations for radioastronomy, the hydrodynamics of cloud droplets and for computations for other divisions of the Csiro (crystallography, data and time series analysis, relaxation techniques for structures design and solution of partial differential equations for heat flow and hydrodynamic studies). It was also used by the McMaster Animal Health Laboratory of Csiro for statistical analyses. From 1954 the installation was operated by the H N Turner, of the McMaster Laboratory.

A number of projects required various amounts of multiplication. At first a BTM

(Continued page 24)



■ ***Maston Beard teamed up with Trevor Pearcey in 1949. Beard worked on very early programming techniques.***

HISTORY OF AUSTRALIAN COMPUTING

■ *John Bennett, who recently retired, was a pioneer of the British Edsac project before returning to Australia to join the Silliac project in 1956.*

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tabulator was rewired to perform 10 x 10 digit multiplications. As the demand for multiplication increased, and because shortage of US dollars made the aquisition of multiplying punches from the US impossible, a relay decimal multiplier based upon a reduced biquinery code and containing about 500 type 3000 PO relays was designed, built and coupled to a standard card summary/gang punch.

From late 1950 the Mk1 was continually improved and progressively applied to many types of computational problems met with in Csir/Csiro, some university and government departments and organisations such as the Snowy Mountains Hydro-electric Authority (SMHA), although NSW industrial power troubles seriously delayed progress — a mass of vacuum tubes did not take kindly to the sudden onset of a blackout.

Late in 1948 Myers also visited some of the UK computer projects at Csir's request and, in 1949, advised that work on development of computing machinery should be confined to components only, at least until a cheap and reliable directly accessible storage medium became available as the present acoustic, secondary emission tube and moving magnetic surface seemed to be inadequate. This advice affected what followed.

The first Australian computer conference was held in 1957

The new Section of Mathematical Instruments, now established at the Department of Electrical Engineering, made one of its first projects the construction of an electromechanical differential analyser. Completely electrical methods of integrating continuous variables and of performing arithmetic operations of addition and multiplication on them and transmitting their values electrically had been developed into successful instruments which were much easier to set up and run than the all-mechanical analyser.

However, a new combination seemed possible and cheaper. This scheme was part mechanical and part electrical, using, for mechanical integration, parts from wartime Kerrison predictors and specially designed mechanical adders and gear train multipliers. Input and output angular movements to and from these were transmitted electrically by incremental M-motors that transmitted 16 incremental positions per revolution. The receiving, input, motors provided sufficient torque to drive identically their attached mechanisms thus avoiding the use of mechanical or electrical torque amplifiers.

Units were interconnected via a plug patchboard, which was less costly and also compact and simplified and shortened problem design and set-up times. Such a system was constructed by Myers and W R Blunden.

The machine was built up to 10 integrators, six adding units, six adjustable gear boxes, with four plotting tables for input and output, together with several other auxiliary units. Overall accuracy of 0.1 per cent was obtained. Setting of all gear ratios in intervals of 0.01 per cent between 0.3 and 1.0 was possible and the independent variable could be driven over a wide range of speeds from a controlled servomechanism providing there was no incremental slippage of the M-motors. Unit frame design and castings were made by the Commonwealth Aircraft Corp, Lidcombe, NSW, and the Government Small Arms Factory, Lithgow, NSW.

The combination of mechanism and simple electrical transmission was an innovation although built when the analogue instrument was being overtaken by the new digital machine. It was very effective and was used by various goyernment departments and the SMHA, on problems in nonlinear mechanics, discontinuous servo studies, relaxation phenomena, frame bending, hydraulics and hydrodynamics.

Significant moment

The first computer conference in 1951 was opened by Emeritus Professor Sir John Madsen. It was to be a significant moment for computing in Australia. It was attended by 186 people from universities, government departments and industrial and commercial companies from all States. A special visitor was Prof Hartree, then Plummer Professor of Thoretical Physics at Cambridge University. Hartree was an expert in the use of numerical methods in theoretical physics and a principal supporter of the Edsac and other projects in the UK and elsewhere.

The published proceedings of the 1951 conference show development activities in a number of areas. These included design of magnetic switches, special binary gating vacuum tube counting and shifting devices which were for functions necessary in digital computing (C B Speedy), the design of vacuum tube beam counters and pulse generators (D L Hollway), working models of which had been built in the Csiro Valve Laboratory under R E Aitchison, the first magnetic drum system in the country (W R Blunden) and the development at the University of Adelaide of an analogue device for the solution of polynomial equations up to the fourth degree using commercially available magslip resolvers and variac auto-transformers for its principal computing elements (E O Willoughby, G A Rose and W G Forte).

During the next three or so years the Mk1 was applied to as large a variety of problems as possible to gain operational experience and programming expertise.

First computing laboratories, 1951-57

Although the machine was not offered for use on an open shop basis many computations were carried out on an increasing scale although not all attempts were completely successful. The machine and its operations were valuable as a means of providing many visitors to the laboratory with their first experience in electronic computing. For some time the Mk1 was the main instrument for the spread of such expertise in the country. Among these visitors some, such as John Overstone, B E Swire and E T Robinson, were later to have a significant effect upon Australian computing.

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IN 1951 Professor Hartree was commissioned to advise the Csiro on the future course it should adopt towards computing. It is understood that he advised the setting up of a Division of Applied Mathematics, the functions of which should include research in computing and computing machinery. Presumably, on the basis of that advice, the matter of setting up an appropriate facility was referred to the late J C Jaeger, then Professor of Mathematics at the University of Tasmania, a consultant to the Csiro, a frequent visitor to the Division of Radiophysics and interested in the work on the Mk1.

But Jaeger declined to head the division and thus passed the first opportunity for establishing effective research and development, and a possible future industry in computing for Australia, starting with the combination of the SMI and the Mk1 project and their workers as an embryo Division of Applied Mathematics.

The position changed during 1954, resulting from the failure of the Csiro to establish a positive policy toward computing research and development and following the appointment of Harry Messel to a new Chair of Physics at the University of Sydney in September 1952. Messel took up his position in 1953 as Head of the University's School of Physics and immediately brought new progressive attitudes to the scene of Sydney's academia and a decision to establish a school of research in nuclear physics.

Research foundation

Dr J Blatt was appointed Reader in Physics and on June 8, 1953, the Nuclear Research Foundation (NRF) was established by the University Senate with a membership of about 75 prominant businessmen and organisations as contributors toward its funding and its council of 14 governors was appointed on December 21.

It was clear that research would involve the collection and handling of large volumes of data and much computing would be involved in the theoretical and experimental researches being planned. An efficient and fast instrument for carrying out the computations would be required. On the recommendation of Messel and Blatt it was decided to acquire an electronic computer. Estimates of the computing speeds required indicated that a version of the Mk1 would be quite inadequate.

It was known that the F C Williams' CRT secondary emission method of electrostatic storage, developed at Manchester University and tested on the MADM, had achieved adequate reliability and was in successful operation in a number of US laboratories including Oak Ridge (Oracle) and University of Illinois (Illiac), both built more or less to John von Neumann's (and Eckert/Mauchly's through the Edvac) logical design for the Institute of Advanced Studies machine.

Early in 1954 it was decided to build a version of the Illiac, plans, circuit diagrams and component samples of which were made available to the NRF following negotiations by Dr Blatt. The machine was to be built locally, with local expertise, within 2½ years, to be sited and operated within the School of Physics as a research and service tool for use by the NRF and others. Although the machine was based largely on the design of Illiac and similar machines in the US, some modifications were made.

To fund its construction an appeal was launched on January 8, 1954, for $50,000. On February 12 the entire sum was donated by Dr A Basser (later Sir Adolph). B E Swire, a Sydney graduate in electrical and mechanical engineering, and then at the Aeronautical Research Laboratory, was appointed chief engineer. Before

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■ *Sir Adolph Basser (right) and M W Allen in 1957 with Ada (Automatic Digital Analyser), Australia's first solid state system.*

HISTORY OF AUSTRALIAN COMPUTING

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his essential visit to the University of Illinois he spent some time with the Mk1. On his return work was well advanced and delivery of major components commenced in August. By June 13, 1956, assembly was complete and the first program was run on June 24.

Barry Ferranti joined the construction group toward the end of 1954, having spent some time en route from the UK at Illinois, and John Bennett was appointed to the project in February 1956. Bennett was a graduate in civil engineering from the University of Queensland and had spent four years in the RAAF during WWII on ground radar after attending a course in radiophysics at the University of Sydney's Department of Physics, given with the assistance of the Csir's Division of Radiophysics. As part of further study in engineering, physics and mathematics under the Commonwealth Reconstruction Training Scheme he worked for some months at the Csir's Division of Electrotechnology, whose chief was Myers. It was there that he began his connection with computing and computing devices. Later, in 1946, while becoming further involved with performing heavy computation, he decided to pursue the field of computing more definitely. In September 1947 he became the first research student of director, M V Wilkes, at Cambridge University's Mathematical Laboratory, where the Edsac, the first true stored program computer to be put into regular service, was being designed and built under W Renwick.

Bennett was one of the pioneers of the Edsac team in design and development of programming techniques, particularly interpretive methods, and was with the Ferranti Company from 1950 until his return to Australia. He reorganised the code structure of the Ferranti Mk1, a manufactured version of the MADM, and its programming scheme, no doubt using his Edsac experience. The resulting system was the much more manageable Ferranti Mk1*, a development of the Mk1 and built to Bennett's specifications. In 1953 he moved from Manchester to Ferranti's new London Computing Laboratories where he initiated the design of the Ferranti Perseus computer, a system designed primarily for the insurance industry.

The Silliac (Sydney Illiac), as it was now called, and the Adolph Basser Computing Laboratory which was to operate it, were formally opened by the Governor of NSW, Sir John Northcote, on September 12, 1956, when Dr Basser made a further donation to the laboratory to complete the funding of the machine. The total cost of the Silliac was thus funded by Dr Basser and he was later to add to his support with a further donation of $25,000 to provide the Silliac with three magnetic tape store drives. The machine was completed and operating six months ahead of schedule!

Technically, the Silliac operated in a 40 binary digit parallel manner, having 1024 40-digit words of directly addressable store. Although operands were of full word length, each instruction was of 20-digits only, thus extending the program capacity. It could execute instructions at rates at least an order faster than the Mk1: add/subtract at 13,000/sec, multiply at 1500/sec, decisions at 12,000/sec. It communicated with users via standard five-channel punched paper tape at an input rate of 200 char/sec and output at 60/sec. All pro-

gram coding and recording for input and printing of output tapes was performed off-line away from the machine. It contained about 2000 miniature vacuum tubes but other electronic components were standard and chassis-mounted. It required some 20kW of power and a relatively large capacity air conditioning plant for cooling circulated air. At a later stage the Silliac was provided with three magnetic tape drives and electronics designed by Swire.

The computing services of the Silliac were made widely available almost immediately and many learnt their initial computing expertise by practical experience of it through the open shop policy adopted by Bennett.

The Silliac continued in active service for 12 years and was formally decommissioned in May 1968. Most of its work had been taken over by an English Electric KDF9 (installed in 1965) and an IBM 7040/1401 system (operational in the second quarter of 1967). For some time Silliac acted as a peripheral to the KDF9. Later a Control Data 1700 and a DEC PDP 8/338 were added, both small computers for special purposes.

The IBM 1401 was principally used for transfer to and from industry compatible magnetic tapes while the Silliac was used to spool printer output from the KDF9. The CDC1700 provided an interface for a number of keyboards, using the KDF9 in its multi-programming mode. The whole was integrated into a local intercommunicating network of dissimilar systems by B G Rowswell, C S Wallace and R Cullen. The engineering design of this early network was carried out by Wallace, later to become Professor of Computer Science at Monash University.

Concurrently with the start of the Silliac project, the Director of the University of Technology, Professor J P Baxter, also then chairman of the Australian Atomic Energy Commission, had received in August 1954 a grant of $250,000 from the State Government to support research in nuclear engineering. It was decided that it be used to obtain a fast electronic digital computer together with an analogue instrument (later called the Utac) to provide a means of solving problems in reactor design and for other purposes.

Serial mode

The machine chosen was the English Electric Deuce, the design origins of which stemmed from those of A M Turing's planned ACE, later to be realised first in a reduced experimental form as the Pilot ACE at NPL. It also bore some similarity to the Mosaic designed by Flowers' group at the UK Post Office Research Laboratories. These machines were based upon serial mode of operation somewhat similar to the Csiro Mk1 although separately conceived, with acoustic delay storage, but with much more complicated instruction formats in order to attain high instruction execution rates. But this made direct programming a much more complicated task than for the Silliac or the Csir Mk1.

The Deuce, Ace and Mosaic were also punched card oriented for input and output, using more or less standard BTM summary/gang/reader punches which operated at 100 cards/min, whereas the other two systems were paper tape oriented, although the Mk1 retained a card-like format. The mercury delay line store, which operated at about 1M-bit/sec, was augmented by a fast synchronous magnetic drum of 8192 32-bit words with an 11/msec access and 35/msec block transfer time. The machine contained about 1300 vacuum tubes of types similar to those in Silliac. It dissipated about 10kW of heat.

The machine arrived in August 1956 and was installed in the new University Computing Centre by engineers from English Electric. Prior to that date Ray Smart spent a period at the company's plant at Stafford to study various aspects of design, operations and programming and was present during manufacture and testing. Some engineering modifications were made for the university's purposes.

The Csiro Executive decided to get out of computer design in 1954

The computer was formally named Utecom. It remained in use as a research instrument and for some educational purposes such as aquainting users with programming methods, and so on. It seems likely that it was not operated in an open-shop manner like Silliac as it was a more complex machine to handle. It remained in very effective service for 10 years until 1966, when it was replaced by an IBM 360/50.

The University of Melbourne accepted Csiro's offer to take over the Mk1 in 1954. A computer laboratory was set up under Professor (later Sir Thomas) Cherry and F Hirst was made operations manager.

It seems that the Csiro Executive had decided to remove itself from the field of computer design early in 1954, even though a quantum advance beyond the Mk1 was possible with the Cirrus. Presumably this decision was taken in favor of concentrating resources on the new subjects of radioastronomy, in which Australia was already a leader, and on cloud physics, which showed promise for application to Australia's benefit, although the Mk1 was being applied to further both those subjects.

Hirst spent some time with the Mk1 before the machine was dismantled. It was reassembled with some engineering

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■ *John Ovenstone was a computing pioneer with the Woomera operations.*

HISTORY OF AUSTRALIAN COMPUTING

(Continued from page 27)

Work for the Department of Defence set the scene for acceptance of computing systems throughout Commonwealth government departments

modifications, but no structural logic changes, by Beard and the Csiro Radiophysics engineering team. The machine was formally handed over to the University of Melbourne Csirac Computing Laboratory on June 14, 1956. The Mk1, now the Csirac, was the first electronic computer in Melbourne and still the first to go into regular academic service. The machine was decommissioned on November 24, 1964, when it was replaced by an IBM 7044/1401 combination.

Of the first three machines in the country only the Csirac has survived. It was donated to the State Science Museum of Victoria where it was stored until loaned to the Caulfield, now Chisholm, Institute of Technology, where it is now on view. It is probably the most complete machine that has survived its period. Unfortunately the Silliac and Utecom were dismantled and the parts distributed.

During the period leading to 1957 when the Basser, Csirac and UNSW computing laboratories were operating satisfactorily, other arms of the Commonwealth government had been developing to the stage at which high speed computing was essential. The Weapons Research Establishment (WRE) had been established at Salisbury, near Adelaide, as a local base for its firing range operations at Woomera. Telemetry and ground flight data were being collected in massive quantities and conversion and analysis by the usual hand and desk machine methods of computation were falling far behind requirement, causing serious delays to the firing program. The problems in programming computations performed by large numbers of people in a staged manner was as slow and expensive as it was labor intensive.

J A Ovenstone, who had graduated in physics and mathematics at Sydney in 1950 under the Commonwealth Reconstruction Training Scheme following service with the AIF in the islands, became interested in numerical mathematics and its applications on attending the first undergraduate course in that subject given by Pearcey at the Department of Mathematics of Sydney University under Professor T G Room. His undergraduate project work was on the mechanisation of numerical problems with Pearcey, using the BTM punched card system operated at the Csir RP with the Mk1.

Ovenstone joined the staff of WRE and was seconded to studies at Cambridge. In 1950, prior to the 1951 conference, Ovenstone became a research student at the Mathematical Laboratory University of Cambridge under Hartree, working on the mathematics of the separation of the viscous hydrodynamic boundary layer which exhibited mathematically singular, and correspondingly numerical, conditions. He therefore became aquainted with, and extensively used, the Edsac and its programming philosophy.

He was awarded a PhD in 1953, returned to Austalia as a member of WRE and became involved in solving the data processing problems of the establishment. He became responsible for the design, installation and operation of WRE missile information gathering at Woomera and data processing systems at Salisbury. Through his pioneering efforts a scheme was devised for integrated automatic handling of telemetry radio-doppler and radar data recorded on magnetic tape in analogue form during flight, ground sited flight data, and so on. In his scheme the analogue data was later converted to digital form at Salisbury and then subjected to calibration corrections and numerical analysis by a somewhat modified commercial machine, an Elliott 401.

This machine, called Wredac (WRE Digital Automatic Computer), was organised around a magnetic drum of 16,384 x 34 (orginally 32) bit words for its main store and an execution store, for the immediately running program and data, of 512 words held in magneto-strictive delay lines. It was one of the last of the UK designed and built vacuum tube machines which operated in a serial fashion with a simple one address instruction format somewhat similar to the Edsac, which had more or less established a norm. Data was input basically from paper tape and ¼in magnetic tape recorded at the range. Output was via paper tape, teleprinter and magnetic tape, which was then passed for conversion and graphical output on to a specially devised output converter system which used modified standard facsimile machines.

Flight trials

The Wredac was delivered in October 1955 and completed its acceptance tests in July 1956. Its operation as a flight trials data reduction system with the data input and output converters for transcription of results from magnetic tape to viewed copy began in September 1956.

The system pattern of magnetic tape conversion-computer reduction, magnetic tape conversion, designed by Ovenstone remained for the next 25 years although both converters and computers were replaced by solid state equipment such as the IBM 7090 magnetic tape-based system and IBM 1401 for input and output functions. That such a system was achieved was largely due to the support given to the scheme by the then superintendent, R W Boswell, who clearly understood the importance of computers and computing knowledge to the future of Australia and its armed services.

A number of papers presented by Ovenstone to the 1957 conference on Automatic Computing and Data Processing (which he largely instigated) showed his gathering interest in commercial and administrative applications of computers and there is no doubt that it was at this time that he was gathering expertise in this field which was to bear fruit later in the Department of Defence and to set the scene for other Commonwealth Departments.

This conference, and experience with the Elliott 401, Wredac, was to lay the groundwork for the next major development by Ovenstone in the early 1960s, that of the systematic administrative/technical

Solid state systems, 1957-63

data processing for the armed services and the Department of Defence. His later work for the Department of Defence was to set the scene for the acceptance of computing systems as effective administrative aids throughout the Commonwealth government departments.

The Wredac was publicly exhibited at the 1957 conference as was a machine, also built at WRE, of a different kind. This was an advanced electrical analogue system simulator called Agwac (Australian Guided Weapons Analogue Calculator) designed and in use from 1955 to 1960. It was the last of its kind and the end of the use of analogue technology although some electronic analogue simulation systems of the differential analyser type continued to vie with general purpose machines for some time since, as they effectively operated in a highly parallel manner, they were faster than programmed digital systems and could run in realtime.

A number of papers of the Conference showed continuing interest in analogue devices, mainly for data recording and automatic control. However the execution speeds of digital systems were increasing quickly and were to overtake those of the analogue devices in due course.

The Wredac continued in operation for 10 years from 1956 until 1966 when its work was fully taken over by the faster and more convenient magnetic tape-oriented IBM 7090/1401 combination.

The first signs that solid state electronics was to have a major effect on the design of computers as the new surface barrier junction transistor, with its high switching speed and reliability, became available were discernable in one paper presented to the 1957 conference. This was a report on the design of the ADA digital differential analyser by M W Allen.

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LET US now return to the less obvious activities that took place in the SMI before 1959. It is there we find significant work being performed on the design and construction of relatively small machines.

The first important project in the design and construction of digital machines by the Section was also to create the first entirely transistorised machine in the country and marked the true transition in Australia from analogue and vacuum tube based systems to all solid state digital systems although some early solid state components had been included in machines such as the Mk1 which contained some 500 germanium diodes.

This was the Ada (Automatic Digital Analyser, or after Ada, Countess Lovelace, Babbage's programmer?) designed and constructed by Murray Allen on logic principles based upon a previous US system, such as the Bendix D-12, which used vacuum tube technology. Design commenced later in 1955 and construction commenced in 1956 when suitable surface barrier junction transistors became available.

Once again a major contributor to funding its construction was Dr Basser. Some funding support was also provided by the SMHA. The machine was officially inaugurated by Dr Basser at a ceremony held on March 11, 1958 at Newcastle, NSW.

Allen was a graduate in electrical engineering from the University of Adelaide and had joined the Csiro's SMA following a period with AWA's Research Laboratory. He was later to contribute to Australian computing engineering in a major way.

The digital differential analyser had considerable speed advantage over mechanical versions because it was logically structured similarly to the analogue differential analysers and not as a general purpose digital computer. The use of transistors reduced the power consumption to 60 watts and the size to that of an office desk, 10 per cent of that of a corresponding vacuum tube version. It was also much more reliable. It also allowed reduced setup times since all logic arrangement and data coding could be done off line while the machine was running on another job. The speed was in fact sufficient to allow simulations to occur in real time.

Unlike mechanical, or later electrical, differential analysers, an entirely serial mode of operation was adopted in which the independent variable was incremented periodically and the consequence of an incrementation was followed through the logical network setup, the same arithmetic units and scaling circuits being used at each stage.

Compared with mechanical analysers of

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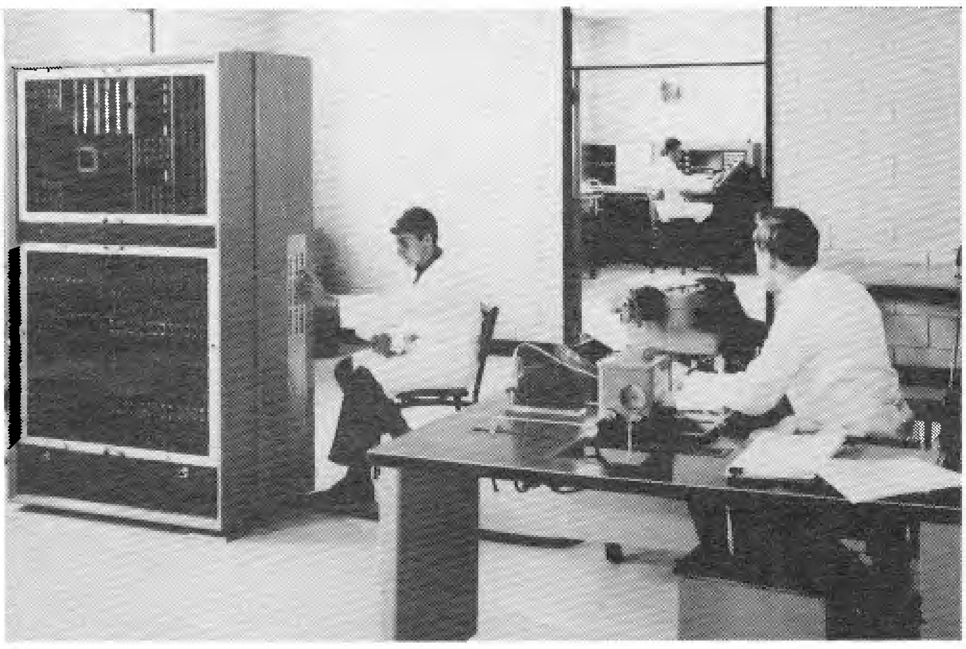

■ *The white coat age . . . Cirrus up and running in Adelaide. Bob Potter is at the desk and Werner Dorfe is at work in the laboratory. The author would like to identify the machine console operator.*

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8 to 12 integrators, the Ada used a 1,1,2,5 decimal coding and had a capacity of up to 60 integrators each having four registers of seven decimal digits. Storage and flow of data was based upon a 16-track magnetic drum which was designed, surfaced and headed inhouse.

The drum had a read/write speed of 129K (as usual in the computing field the symbol 'k' means a factor of 1024) digits/sec which allowed 50 incrementations of the independent variable per second.

Input of set up data, constants and tables was by standard five-channel paper tape which had become popular by that time with some US systems and most UK machines. (The battle between paper tape and cards was to be waged commercially.)

Output was via a modified IBM typewriter which operated without interruption to the steady flow of the machine's operation.

Although the machine was operated effectively from 1958 it was superseded by more general purpose machines to follow such as the next product of the section, namely the Snocom, when operational studies made on the Silliac for SMHA showed that a stored program machine could be more effective and flexible.

The Snocom was the product of the SMI, this time entirely funded by SMHA and intended for its use at its headquarters at Cooma, NSW. Again Allen was the designer basing its logical structure on that of the small US produced LGP 30 vacuum tube and magnetic drum system. This time a proven commercially available magnetic drum made by Bryant was the main storage medium. The transistor types and circuit and packaging techniques were those developed for the Ada.

The machine was a relatively simple fixed-point, serial, stored program computer with a drum store of 2048 32-bit words arranged around 64 tracks each of 32 words. A simple set of 16 one-address instructions in a format much like that of the Silliac or Edsac was used.

Snocom was installed at SMHA, Cooma, in 1960 and was in reliable service until 1967 when its work was taken over by another system which had been installed there, somewhat earlier, essentially for administrative purposes.

Snocom was returned by SMHA to the University of Sydney's Department of Electrical Engineering in August 1967 where it was used occasionally for demonstration and student teaching.

In May 1982 it was offered and accepted for the National Collection of the Australian National Museum at Canberra.

It is to be noted here that the SMI ceased as a section of Csiro in 1959 when D M Myers left for Canada and the staff (including W S Lamond, L G Bellamy, J E Todd, R B White and K R Rosolen) continued at the university department with W Christiansen's, and later H Messerle's support.

This definitely terminated any involvement by Csiro with computer design and effectively discouraged any further work in Csiro on computer architecture, the study of computer structures.

The experience gained by M W Allen and also by D G Wong of the department was to be of importance later during the early 1960s.

The fund of experience in transistor digital electronics in small-machine design of office desk size that now existed could then have led to establishing a successful, and profitable, small, special-purpose machine industry if the opportunity presented had been taken. Better opportunities were to be offered later that were also not pursued!

From 1959 into the early 1960s a number of significant happenings occurred which not only had effect upon commercial designs but also drew Csiro back into the computer field, but only in the service and software areas.

The decade of the 1950s had seen the development by overseas interests of large capacity magnetic tape based computing

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systems. These tended to divide into two classes as they were oriented toward fast execution of complex arithmetical programs for scientific computations or increasingly complex administrative data processing requiring less arithmetic but more symbol processing and larger quantities of data input and output.

In both types of system there was a shortage of fast accessible storage to maintain maximum program execution and data access rates to keep programs running.

Essentially mechanical input and output devices were much slower in operation than internal electronics and, particularly with the latter type of system and application, program execution rates were seriously slowed up while the system waited for input and output devices to catch up with the electronics.

Early machines, like the Mk1, and the magnetic drum based machines, were limited mainly by the slow access rate to their, so-called, fast store so that instruction execution rates were limited to millisecond times although they had the advantage of electronic simplicity because of their serial nature.

Silliac was much faster because it operated in parallel mode, operating upon all bits of a word concurrently, and because it directly addressed its main program and data store without having to wait for an addressed word to become available. Nevertheless the electrostatic, Williams, tube store of Silliac was basically unreliable for a number of reasons although the record of Silliac was excellent for its time.

The cost per bit of fast storage of the 1940s and 1950s was too high for systems to be given more than a few thousand words of fast storage and a complicated method of transferring, under program control, blocks of data and program between that stored on a slower but, larger and cheaper/bit medium, had to be devised and incorporated, such as to and from magnetic tape and/or magnetic drum.

All the types of storage media then in use, including the magnetic tape and drum, which lay between the directly addressable and the "external" media devices such as paper tape and punched card and hard copy printing attachments, which were even slower, suffered the disadvantages that D M Myers had pointed out to the Csiro Executive earlier.

These disadvantages were overcome in the early 1950s by the invention by J W Forrester, then Director of the MIT Project Whirlwind, of the array of toroidal ferrite "cores" for storage, first with a cycle time of 20 microseconds. The use of ferrite

■ *The pioneering Ada (Automatic Digital Analyser) designed in 1955 by Murray Allen with the then revolutionary solid state technology.*

materials with hysteresis properties was then new. The magnetic core array was to become the main fast read/write storage medium for the next 20 years, and industrial development was to progressively reduce the cycle time from 20 microseconds to less than two microseconds before it became superseded by silicon integrated microelectronics.

During those two decades the advantages of any new storage technology was amply met by improvements in ferrite core technology.

Nevertheless while core technology allowed directly addressable store to be increased from, say, 4K words to 32K words it was still, by modern standards, expensive; it did however allow of increase in execution speeds of an order of magnitude when the 6 microsecond, and then the 2 microsecond core became available.

While the large commercial systems were mainly designed for large volume processing, in the scientific, technical and business areas a line of development was going on direct toward the lesser volume applications. Thus developed the line of office desk sized, mainly serial, systems such as the Ferranti Sirius, the IBM 1620 and the Control Data 160 and 160A. The present day equivalent of these is, of course, the much more powerful personal computer based upon large-scale integrated microelectronic technology.

The combination of technical difficulties just mentioned led, particularly in open-shop types of service usage, to increasingly inefficient use of machine processing capability. This was a serious matter especially for the use of the large expensive systems in which much time was occupied in online program proving.

The attempt to avoid such losses led to the closed-shop method of operating large expensive systems where the actual user was denied direct access to the system which was operated by a special staff who collected users programs and data on external media, or even recorded the material themselves from users, paper statements of program and data, ran and returned listed outputs. Such methods were of course unpopular with the endusers since the elimination of "bugs" in their programs became a long and slow process.

Further, the task of constructing and recording user programs became possible when machines became more powerful and faster. The old method of programming in "assembly language" and coding on to the external medium had to be reviewed.

This led to the development of new and easier methods of program statement and more sophisticated programs for their conversion by the machine itself to forms which the machine could handle directly and for which it could provide some significant levels of failure diagnosis. Thus were to arise the macro-assembler, user oriented languages, interpreter and compiler techniques for making programs executable when presented in simpler forms.

While attention of the computing fraternity and the main system suppliers was concentrated upon these matters, machine architects and designers consequently restricted their attention to large general purpose systems and neglected the possibility of designs oriented, for cheapness and speed, toward special types of task.

We can see this trend, and an indication of future opportunity, in the development of the Cirrus system at the University of Adelaide between 1959 and 1962.

Work by Pearcey, Hill and Ryan on the Mk1, well before its transfer to Melbourne, had indicated the power of the use of macro- and higher level languages and their processing programs. Further it was becoming clear that the availability of a cheap and fast form of read-only store to hold commonly used and accessed programs as standard subroutines and data permanently available within the system would be a preferred way of assisting the construction and execution of user's programs.

A form of read only store built into the architecture of the computer using a cheap technology, of which there were a number of promising lines for development, could become important components in future systems. This was to be seen later to be more general than then believed.

Pearcey, when working at TRE in 1957 and 1958 on the Treac machine, a fast, parallel, Williams-tube and drum system resembling the Silliac in architecture, assisted in the construction and use of a read-only subroutines store for the Treac. This consisted of one plane of 24 x 32 6-microsecond score threaded by a number of digit wires, one for each word, accordingly as the particular bit of the word of each wire was unity or zero.

Some 64 wires threaded each of the 32 lines of cores and each was selected for readout as a running program called for them. This gave a set of 2048 words of library subroutines which a user could call upon without incorporating them directly within his program.

He also became aquainted with the new Edsac II then operating at the Cambridge Mathematical Laboratory. This was the first machine to, in effect, operate by a process of wired in interpretation using a matrix of linear ferrite cores instead of the hysteresis cores used in read/write stores. This was a process, called "microprogramming" by M V Wilkes, the originator of the technique.

Although this technique was to go unregarded for a number of years both in the UK and US, the principle of use of fast, cheap read-only storage at a variety at levels of a computer's organisation was realised. It was to be used immediately in Adelaide.

● ***Trevor Pearcey returned to Australia in 1960 as a member of Csiro's division of mathematical statistics. In a future extract from his History of Australian Computing Pearcey traces the continuing development of solid state technology and the pursuit of greater and greater computing power.***